THE DESCRIPTION and USE OF A QUADRANT,

BY WHICH

All the moſt Uſeful and Neceſſary Propoſitions of both the GLOBES are eaſily and exactly performed; as the *Right Aſcenſion, Declination, Altitude, Amplitude, Riſing, Setting, Azimuth,* and *Hour of the Day.*

ALSO OF A

QUADRAT,

BY WHICH

You may take all manner of *Height* and *Diſtances,* as of *Towers, Steeples, &c.*

AND LASTLY, OF A

NOCTURNAL,

FOR THE

Ready finding of the *Hour of the Night.*

Publiſhed by *J. H.* for the uſe of ſuch as are Mathematically affected.

London, Printed for the Author. 1672.

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TO THE READER.

READER,

THOU *art here presented with the Description and Use of a small Portable Instrument called a* Quadrant, *by which all the most useful and necessary* Problems *of both the* Globes *may be easily and exactly performed, and also*

ſo ſuch Propoſitions in Geometry *as concern the taking of Heights of Buildings, Diſtance of Trees or other Objects, Depths of Wells, or the like.*

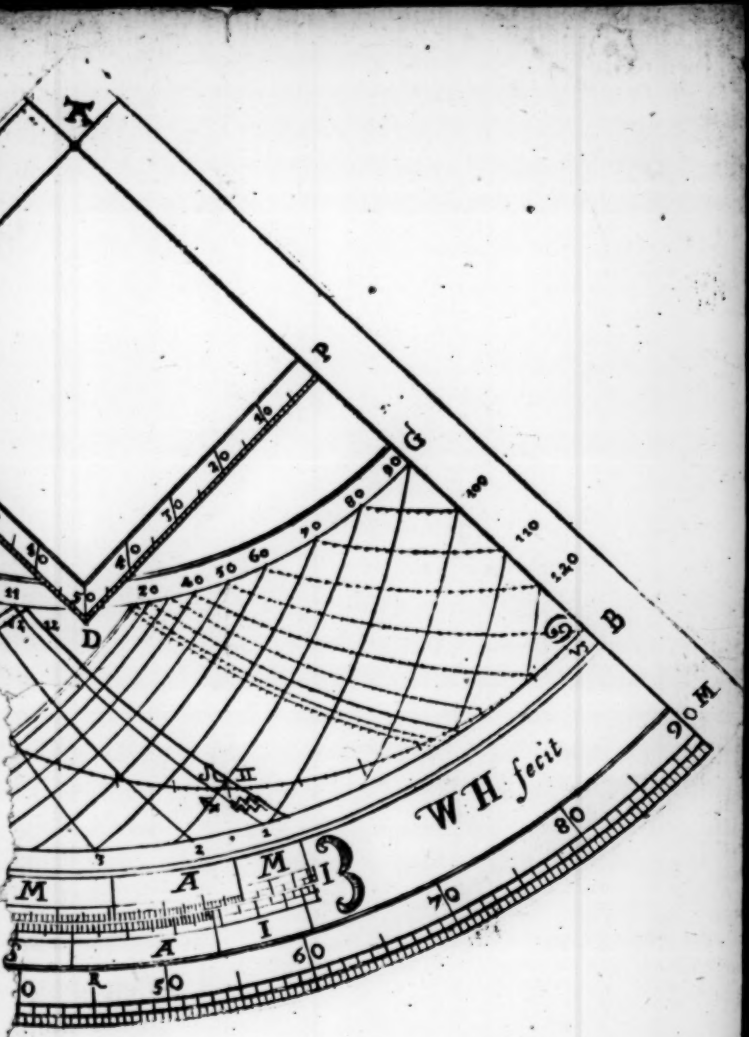
The Inſtrument is in it ſelf Portable, *in its Uſe* Eaſie, *and in its Performance very* Exact. *If any ſhall think other* Quadrants *more accurate in their* Projections, *ſo do I; but not ſo eaſie in* Practice,

ctice, *nor of ſo ſmall a* Price: *For which Reaſons I do chiefly prefer it, deſiring thee to make uſe of this, till I preſent thee with ſome other of this kind, which (if I find this* accepted) *ſhall be ſhortly: And in the mean time,*

Vale.

ADVERTISEMENT.

IF *any Gentleman, ſtudious in the* Mathematicks, *have, or ſhall have occaſion for Inſtruments thereunto belonging, or Books to ſhew the Uſe of them, they may be furniſhed with all ſorts uſeful both for Sea or Land, either in Silver, Braſs, or Wood, by Mr.* Walter Hayes *at the* Croſs Daggers *in* Moor-Fields, *next door to the* Popes-Head *Tavern, where they may have all ſorts of Maps, Globes, Sea-Plats, and Mathematical Paper, Carpenters Rules, Poſt and Pocket-Dials for any Latitude, Steel Letters, Figures, Signs, Planets, or Aſpects, at reaſonable Rates.*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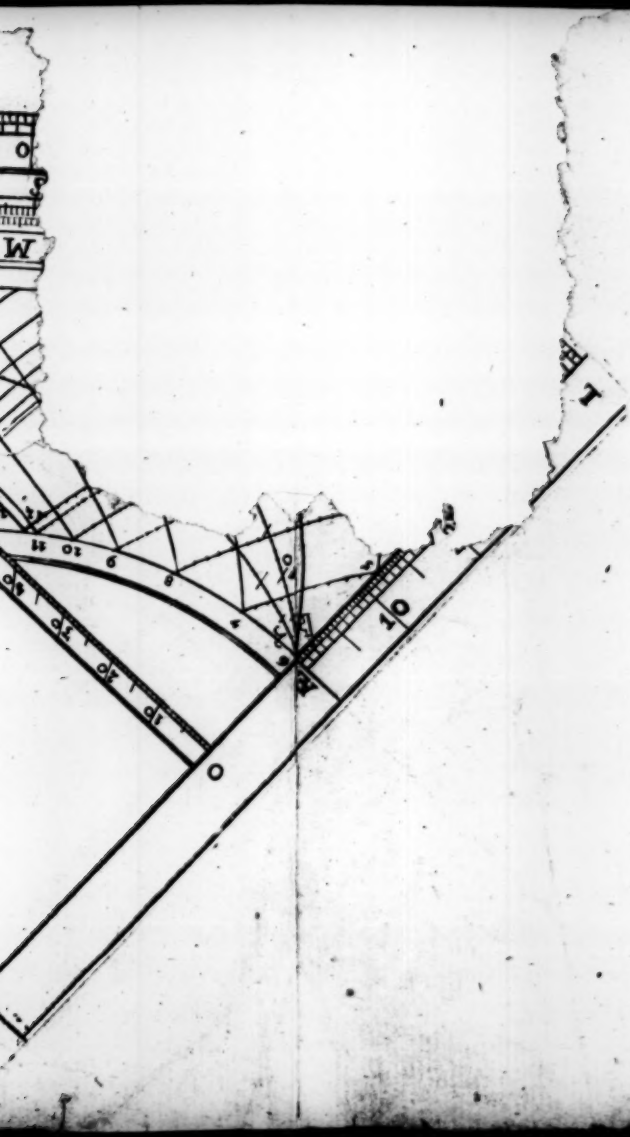
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THE DESCRIPTION OF THE QUADRANT.

BEfore I come to ſhew the ſeveral Uſes of the Quadrant, it will be neceſſary, firſt, to let you know what a Quadrant is; and then, ſecondly, to deſcribe unto you the ſeveral Lines thereon graduated.

A Quadrant, as it is defined by Geometricians, *is the fourth part of a Circle, contained under two Semidiameters iſſuing from the Center of the ſame Circle, and drawn at Right Angles, which is at 90 Degrees diſtance one from the other.* And ſuch is the Figure A L M hereunto annexed; of which Figure, the two ſides A L and

A M are the two Semidiameters, meeting one with the other in the Point A, which Point A is the Center of the Quadrant, in which Point if you set one Foot of a pair of Compasses, and extend the other Foot thereof to L or M, (which Lines are of equal length) if you move the Foot of the Compasses along from L to M, it will describe a crooked Line, as the Line L R M, which Line L R M is called the Limb of the Quadrant; and the whole Figure comprehended within these three Lines A L, A M, and L R M, is called the Quadrant: So then,

A L is one Semidiameter
A M the other Semidiameter
L R M is the Limb
A is the Center
} of the Quadrant.

Having thus defined what a Quadrant is, I will now declare unto you what Lines are described upon this

Quadrant,

Quadrant, and what they are called, how numbered, and to what uſe every particular line ſerveth.

A DESCRIPTION OF THE LINES *that are Graduated upon the* QUADRANT, *and to what Uſes they ſerve.*

FIrſt, The *Limb* of the *Quadrant*, which is the line L R M, is divided into 90 equal parts, called Degrees, which Degrees are ſubdivided into halves or quarters, according to the largeneſs of the *Quadrant*. Theſe Degrees are numbred from I towards M, by 10, 20, 30, *&c.* to 90 Degrees, every fifth and tenth Degree being diſtinguiſhed from the reſt by a longer line.

The Uſe of theſe Degrees ſerve chiefly to take the Altitude or Height of the Sun, Moon, or Stars.

Secondly, Above this Limb L R M (and parallel thereunto) is drawn another crooked Line, as S B in the Figure, which Line repreſenteth the two Tropicks, namely, either that of *Cancer*, or that of *Capricorn*. Now theſe two Tropicks are thoſe two Circles in the Sphere which bound or limit the Suns courſe; for the Sun never goeth more Northward than the Tropick of *Cancer*, nor more Southward than the Tropick of *Capricorn*.

Thirdly, Between theſe two Lines S B and L R M, are drawn two other concentrick Circles, beginning at 15 Degrees of the Quadrant, and reaching to 62 Degrees of the ſame; and theſe two Circles are called *The Circles of Months*. Of theſe two Circles of Months, the undermoſt, which is next to the Quadrants Limb, containeth that

part

part of the Year whinh we call Summer and Autumn, which is from the tenth of *June* till the eleventh or twelfth of *December*, all which time the Days ſhorten to thoſe which live in North Latitude, and lengthen to thoſe that live in the Sourhern Hemiſphere. The uppermoſt Circle of Months containeth that part of the Year which we call Winter and Spring, which is from about the eleventh of *December*, to about the tenth of *June*. In theſe two Circles, each Month, at the beginning of it, is noted with the firſt Letter of that Month which it repreſenteth, as J for *January*, F for *February*, M for *March*, *&c.* Every of theſe Months is divided into Days, every fifth and tenth Day being diſtinguiſhed from the reſt by a longer Line. The Uſe of theſe two Circles of Months is *to rectifie the Bead*, as ſhall be ſhewed hereafter; which Bead being rectified, the Day of the Month

only being known, moſt queſtions of the Globe or Sphere are immediately reſolved with great facility.

Fourthly, Above, towards the Center of the *Quadrant*, is drawn another Circle, noted with Æ G, which repreſenteth the Equinoctial. Now between this line Æ G (the Equinoctial) and the line S B (repreſenting the Tropicks) doth the Sun always move, and never exceedeth thoſe limits; for when the Sun is in *Cancer*, the Days to us are longeſt: when in *Capricorn*, ſhorteſt; and when in the Equinoctial, the Days and Nights are of equal length.

Fifthly, From Æ to B is drawn a circular line upon the *Quadrant*, called the *Ecliptick*, and it is firſt divided into three unequal parts, at the ends of which parts are ſet the Characters of the twelve Signs of the Zodiack, in this order: The Characters of *Aries* ♈ and *Libra* ♎, ſtand cloſe to Æ in this order,

order ♈ ♎ ; then at the firſt of the three diviſions next to Æ ſtand theſe four Characters in this form ♏ ♉ ♐ ♍, which ſheweth, when the Sun is in that part of the Ecliptick line, he is in the beginning of one of thoſe four Signs. At the ſecond of theſe three diviſions are placed theſe four Characters in this order ♌ ♊ ♒ ♑, at which place in the Ecliptick when the Sun cometh, he is in the beginning of one of theſe four Signs. At the end of this line, cloſe to the letter B, are placed theſe two Characters ♋ and ♑ in this order ♋ ♑ to which place when the Sun cometh, it is either the longeſt or the ſhorteſt day in the year; *viz.* the longeſt when in *Cancer*, the ſhorteſt when in *Capricorn*. Every one of theſe three great diviſions are divided into 30 Degrees apiece, and each of them numbred by 10, 20, 30, both backward and for-

ward, according as the Instrument is in largeness This Line is called the *Ecliptick*, and it sheweth in what Sign, and Degree of that Sign, the Sun is any Day of the Year.

Sixthly, There is another Circular Line drawn from Æ to E, which Line is divided into fourty unequal Parts or Degrees, and numbred from Æ towards E by 10, 20, 30, 40, ending at E. This Line is called the *Horizon*, and sheweth every Day in the Year how many Degrees the Sun rises or sets distant from the true East or West Points of the Heavens, which is of excellent use for Sea-men, for them thereby to find the Variation of their Compass.

Seventhly, That part of the Semidiameter of the Quadrant which is between the Letters Æ and S, is divided into 23 and a half unequal parts; which are numbred by 10, 20, 23 ½. This Line is called the Line of Declination,

nation, and ſheweth at any time of the Year how much the Sun in its courſe is declined from the Equinoctial towards either of the Tropicks, by which the increaſe and decreaſe of the Days and Nights are known.

Eighthly, Between the Equinoctial Æ G, and the Tropicks S B, are drawn divers other crooked Lines, of which thoſe 6 Lines which are pricked in this manner ..... and bend towards the left hand, the firſt being numbered with 7 at one end, and 5 at the other, repreſenteth the Hour of 7 of the Clock in the forenoon, or of 5 a Clock in the afternoon: the ſecond is figured with 8 and 4; the third with 9 and 3; the fourth with 10 and 2; the fifth with 11 and 1; the ſixth with 12: and theſe Lines repreſent thoſe Hours of the Day, as the Figures ſet to them do declare. Thoſe nine other Lines which are drawn with a full Line thus ———, and bend towards

wards the right hand, of which, the firſt of them towards the right hand is marked with 12, repreſenting 12 of the Clock at Noon; the ſecond is noted with 1 at one end and 11 at the other, the third with 10 and 2, the fourth with 9 and 3, the fifth with 8 and 4, the ſixth with 7 and 5, the ſeventh with 6 and 6, the eighth with 5 and 7, and the ninth with 4 and 8, repreſenting thoſe Hours of the Day either before or after Noon.

Note, That the ſix forementioned Hour-lines which are pricked in this manner..... are called the *Winter-hour-lines*, and are in uſe only for the Winter ſeaſon, as from the 12 of *September* till the 10 of *March*: And the other nine lines drawn thus—— are called the *Summer-hour-lines*, and are in uſe from the 10 of *March* to the 12 of *September*.

Note

Note alſo, That if the *Quadrant* be made large enough, each Hour may be divided into halves and quarters, or into ſmaller parts; and (as Mr. *Gunter*, the Contriver of this *Quadrant*, rightly ſaith) If it be made of a Foot ſemidiameter, it will ſhew the Azimuth unto a Degree, and the time of the Day unto a Minute.

Ninthly, Between the Equinoctial Æ G, and the Tropicks S B, are drawn, towards the other ſide of the *Quadrant* A M, divers other crooked lines, called Azimuths, in the ſame order and form that the Hour-lines are drawn: of which lines, thoſe that bend from the left hand towards the right, and pricked thus ..... are the Azimuths in uſe for the Winter-ſeaſon, *viz.* from the 12 of *September* to the 10 of *March*: and thoſe that bend

bend from the left hand towards the right, and drawn with a full Line thus ————, are the Summer Azimuths, and are in uſe from the 10 of *March* till the 12 of *September*. Theſe Azimuth-lines ſhew at all times of the Day, and any time of the Year, how far the Sun is diſtant from the Meridian, which is of excellent uſe, not only in Navigation, but in Dialling alſo, and many other good purpoſes: Theſe Azimuths are numbred by 10, 20, 30, 40, *&c.* to 120 Degrees.

Tenthly, Amongſt theſe Hour and Azimuth-lines may be inſerted any Fixed Stars that lie between the Equinoctial and the Tropicks; but becauſe the Quadrant ſhould not be overmuch cumbred, Mr. *Gunter* hath made choice only of 5 ſelect Stars, lying very convenient for obſervation at all times of the Year; and thoſe are theſe: *Pegaſus Wing*, *Arcturus*, *Lyons Heart*, *Bulls Eye*, *Vultures Heart*.

Ele-

Eleventhly, To this Quadrant (as to others) there belongeth two Sights of Braſs, as alſo a Thred and Plummet, with a ſmall Bead or Pins-head, to ſlip up and down upon the ſtring at pleaſure. Thus is the Quadrant fitted to perform the Uſes following.

THE

THE USES *of the Several* LINES *which are deſcribed on the* QUADRANT.

HAving thus given you a true and perfect Deſcription of the ſeveral Lines that are upon the *Quadrant*, it will be neceſſary now to ſhew you the Uſes of them ſeverally, which I ſhall briefly and plainly do in the following *Propoſitions*. And,

I. *Of the Quadrants Limb.*

PROP. I. *How to take the Altitude of the Sun, Moon, or Stars.*

BEcauſe many of the *Propoſitions* following require the *Suns* Altitude to be given, it will be neceſſary to ſhew

ſhew you how to take it by the *Quadrant* at any time, the *Sun* ſhining.

Upon the edge of your *Quadrant* are two ſights for this purpoſe. Take the *Quadrant* in both your hands, laying your right hand ſomewhat neer that ſide that hath the ſights, and your left hand towards the other ſide, by which means you may let it ſlip lower, or raiſe it higher, as occaſion requires. Then turning the left ſide of your Body to the *Sun*, hold the *Quadrant* in both your hands, as is before directed, and move it up or down in your hand, till the *Sun* ſhining through that ſight which is next the Center of the *Quadrant*, do caſt his Ray or Beam of Light upon the hole of the other ſight, at which inſtant, look in the Limb of the *Quadrant* what Degrees and part of a Degree the Thred reſteth upon, for thoſe degrees are the degrees of the *Suns* Altitude. Thus for taking the *Suns* Altitude; but for the

Moon

Moon and Stars you must do otherwise, namely thus: Hold the Quadrant in both your hands, as before, and look through both the Sights till you espy the Moon or Star whose Altitude you require, which when you have found, look what Degrees the thred cuts in the Limb of the Quadrant, for those Degrees are the Altitude of the Moon or Star you look at.

Likewise in the taking of Altitudes of Buildings, *&c.* you must look through the Sights, till you see through them the top of the Object whose height you would know.

II. *Of the Circle of Months.*

BEfore we come to shew the Use of these Circles, it is requisite to shew you to what use the Bead that is upon the string serveth, and how to rectifie or set it for any Day of the Year, which is as followeth.

How

How to Rectifie the Bead.

The Thred being fixed in the Center of the Quadrant, and the Bead upon it, lay the Thred upon any Day of any Month, and there with the Thumb of your left hand hold it faſt, and with the nail of the finger or thumb of your right hand ſlip the Bead upon the thred (either upwards or downwards) till the Bead lies juſt upon the Hour-line of 12, and there let the Bead reſt, for then it is rectified or ſet for that day of the year upon which the thred lieth. This we ſhall hereafter call *The Rectifying of the Bead.*

PROP. 2. *Any day of the year being given, to find what other day of the year is of the ſame length therewith.*

SUppoſe it were required to find what day of the year is of equal

length with the 18 day of *October*. Lay the thred to the 18 day of *October* in the lower Circle of Months, then will the thred lye upon the 2 day of *February*. in the upper Circle of Months, which day is of equal length with the 18 of *October*. In this kind you may find the

March	1		*September* 21.
August	12	equal to	*April* 11.
May	1		*July* 22.

And so of any other day of the year.

PROP. 3. *The day of the month given, to find the Suns place in the Ecliptick.*

LEt the day given be the 16 of *April*, Lay the thred to the 16 of *April*, and rectifie the Bead to 12, as hath been already taught; then move the thred upon the Quadrant till the Bead lieth upon the Ecliptick-line; so shall the Bead cut the Ecliptick-line in *6 deg. 43 min.* of *Taurus*, in which Sign and Degree the Sun is upon the 16 of *April*.

Note,

Note, That from the 10 of *March* to the 12 of *September* the Sun is in thoſe Signs that are characte-red on the upper part of the Ecli-ptick-line (and hath North-decli-nation:) But from the 12 of *September* to the 10 of *March* he is in thoſe Signs that are characte-red below the Ecliptick-line (and hath South-declination.)

So ſhall you find that on

			deg.	m.	
January	12	the Sun	3	12	*Aquar.*
April	26	will be	16	23	*Taurus.*
September	1	in	19	1	*Virgo.*

PROP. 4. *The day of the month being given, to find the Declination.*

UPon the 9 of *April* let it be required to find the Declination.

Lay the thred to the day given, and rectifie the Bead as before; then bring the Bead to the line of Declination, and it will fall upon 11 *deg.* 30 *min.* and such is the Declination for that day Northward.

PROP. 5. *The day of the Month being given, to find the Meridian Altitude.*

THe day given is the 9 of *April*: Lay the thred thereto, and in the Limb of the Quadrant it will cut 50 *deg.* which is the Meridian Altitude.

PROP. 6. *The day of the Month being given, to find the Amplitude.*

LEt it be required to find the Amplitude upon the 15 of *May*: Lay the thred to the day of the Month, and rectifie the Bead; then bring the Bead to the Horizon, and it will fall in 35 *deg.* 8 *m.* which is the Amplitude

tude for that day: For then doth the Sun riſe 35 *deg.* 8 *min.* from the Eaſt towards the North, and ſets 35 *deg.* 8 *min.* from the Weſt towards the North.

Note, When the Sun hath South Declination, the Amplitude of his riſing and ſetting is from the Eaſt or Weſt towards the South.

PROP. 7. *The day of the Month being given, to find the Aſcenſional difference; and thereby the time of the Suns Riſing or Setting, with the length of the Day and Night.*

LEt the day given be the 15 of *May*, Rectifie the Bead for that time, and bring it till it touch the Horizon, then will the thred cut the Limb of the Quadrant in 28 *deg.* 50 *min.* which is the Aſcenſional difference.

From the Aſcenſional difference thus found, may the time of the Suns riſing and ſetting be computed, and thereby the length of the day and night, in this manner.

Convert the Aſcenſional difference into time, by allowing 15 *deg.* to an hour, and a degree to 4 minutes of time. Thus on the 15 of *May* the Aſcenſional difference being found as before to be 28 *deg.* 50 *min.* which converted into time, maketh 1 hour and 55 minutes of an hour; wherefore that day (it being in Summer) the Sun did riſe one Hour and 55 minutes before 6 of the clock, and did ſet as much after 6 at night: that is, it did riſe 5 minutes after 4 in the morning, and did ſet 5 min. before 8 at night.

Now if you double the time of the Sun riſing, you have the length of the night;

night; and the time of the Sun ſetting doubled gives the length of the day. Thus on the 15th of *May* the night will be found to be 8 hours 10 minutes long, and the day 15 hours and 50 minutes long.

PROP. 8. *The day of the month being given, to find the Altitude of the Sun at all the hours of the day.*

HAving rectified the Bead for the day given, move it from Hour to Hour, and what Degrees in the Limb are cut by the Thred, are the degrees of altitude at thoſe hours.

Thus if the day given were the 8 of *February*, the Bead rectified and carried along from Hour to Hour, the Thred would cut the Limb at every Hour in ſuch Degrees and Minutes as are expreſſed in this Table following.

Hours		D.	M.	
XII		27	1	
I	XI	25	40	
II	X	21	51	Altitudes at
III *or* IX		15	58	these Hours.
IV	VIII	8	33	
V	VII	0	6	

III. *Of the Ecliptick-line.*

PROP. 9. *The place of the Sun in the Ecliptick being given, to find the day of the month.*

LEt the place of the Sun given be in 27 *deg.* of *Aries*: Lay the thred upon 27 Degrees of *Aries*, and bring the Bead thereto; then move the thred along till the Bead lies upon the Hour-line of 12, then will the thred cut upon the 6 of *April*, which is the day of the month required.

PROP.

PROP. 10. *The place of the Sun in the Ecliptick being given, to find his Declination.*

THe Sun being in 27 Degrees of *Aries*, let the Bead be rectified thereto, as in the laſt Propoſition, then bring the Bead to the Line of Declination, and it will fall upon 10 *deg.* 27 *m.* which is the Declination for that day Northward, becauſe it is in Summer.

PROP. 11. *The place of the Sun being given, to find his Right aſcenſion.*

IN this Propoſition there is no need of the Bead; for the thred being laid upon the Suns place in the Ecliptick, it will cut the Limb of the Quadrant in the Right aſcenſion.

Let the Suns place given be in the fourth degree of *Gemini*, the thred laid thereto will cut the Limb in 62 *deg.* and

and that is the Suns Right Aſcenſion when he is in 4 Degrees of *Gemini*.

Note, That the Right aſcenſion is numbred from 1 *deg.* to 360 *deg.* and is to be accounted according to the Suns diſtance from the firſt Degree of *Aries*; for if the Sun be more than 90 *deg.* from the beginning of *Aries*, there muſt be more than 90 *deg.* allowed for the Right aſcenſion.

So if the Sun be in 26 *deg.* of *Cancer*, the thred being laid thereto will fall alſo upon 62 *deg.* and yet the Right aſcenſion muſt be counted 118 *deg.* Likewiſe, if the Sun were in 4 *deg.* of *Sagittarius*, the thred will fall in the ſame place, but the Right Aſcenſion muſt then be accounted 242. and if the Sun be in 26 *deg.* of *Capricorn*, the Right aſcenſion muſt be accounted 298 *deg.* The like for any other.

PROP.

PROP. 12. *The Suns place in the Ecliptick being given, to find the Amplitude.*

THe thred laid to the Suns place in the Ecliptick, bring the Bead thereto, then move the ſtring till the Bead touch the Horizon, and it will there ſhew you the Amplitude.

Thus the Sun being in 4 *deg.* 37 *min.* of *Gemini*, the Bead rectified thereto, being brought to the Horizon, will cut it in 35 *deg.* 8 *min.* which is the Amplitude at that time.

IV. *Of the Horizon.*

PROP. 13. T*he Suns Amplitude being given, to find the Declination.*

PLace the Bead upon the Degree of Amplitude given in the Horizon, then bring it to the Line of Declination, and it will there fall upon the

the Degree of the Suns Declination.

So the given Amplitude being 35 *deg.* 8 *m.* the Bead laid thereto in the Horizon, and carried to the Line of Declination, will fall upon 21 *deg.* 9 *min.* the Declination.

PROP. 14. *The Amplitude being given, to find the day of the month.*

THe Bead being laid to the Degree of Amplitude in the Horizon, and carried from thence to the Hour-line of 12, either in Winter or Summer, the thred will fall upon the day of the month.

So the Amplitude being 35 *deg.* 8 *min.* the Bead laid thereto, bring it to the Hour-line of 12 in Summer, and the thred will cut upon the 15 of *May*, and the 7 of *July*, on both which days the Sun hath 35 *deg.* 8 *min.* of Amplitude.

But if it be in Winter, carry the Bead

Bead to the Winter-hour-line of 12, and the thred will fall upon the fourth of *January*, or the 16 of *November*, upon either of which days the Sun hath like Amplitude Southward as it had in Summer Northward.

V. *Of the Hour-lines.*

PROP. 15. *The Altitude of the Sun and day of the month being given, to find the hour of the day.*

HAving obſerved the Suns Altitude, as is taught in the Firſt *Propoſition*, let the Bead be rectified to the day of the Month, and bring the thred to the Suns Altitude, then ſhall the Bead fall upon the hour of the day.

Let the time given be the 10 of *April*: Having rectified the Bead for the day, and found the Suns Altitude to be 36 *deg.* the Bead at that time will fall upon the Hour-line of 9 and 3, which ſhew-

ſheweth that it is either 9 of the clock in the forenoon, or 3 in the afternoon.

But if on the ſame day you obſerve the Altitude to be about 40 *deg.* you ſhall find the Bead then to fall about half way between the Hour-lines of 9 and 3, and of 10 and 2; wherefore the hour muſt be either half an hour paſt 9 in the morning, or half an hour paſt 2 in the afternoon; and which of theſe is the true hour, is eaſie to determine. But if it be neer noon, as between 11 and 1 of the clock, then the ſureſt way to find the true hour is by a ſecond obſervation of the altitude; for, if the altitude increaſe, it is the forenoon-hour; but if the altitude decreaſe, it is the afternoon-hour.

PROP. 16. *The hour of the day being given, to find the Altitude of the Sun.*

REctifie the Bead to the time given, and bring it to the hour given; then

then will the thred ſhew upon the Quadrants Limb the Degrees of the Suns Altitude at that hour.

So if the day given were the 9 of *April*, and the Altitude of the Sun at 8 in the morning or 4 in the afternoon were required. The Bead being rectified to the 9 of *April*, and brought to the hour-line of 8 and 4, the thred will cut the Quadrants Limb in 27 *deg.* 31 *min.* and ſuch Altitude will the Sun have at 8 or four of the clock upon the 9 day of *April*.

PROP. 17. *The Hour of the Night being given, to find how much the Sun is below the Horizon.*

OBſerve this general Rule: The Sun is always ſo much below the Horizon at any hour of the night, as his oppoſite point is above at the like hour of the day: So that if the Queſtion be in Summer, you muſt uſe the

the Winter-hour-lines, and in Winter the Summer-hour-lines.

Let it be required to find how much the Sun is below the Horizon upon the 10 of *April* at 4 of the clock in the Morning. Set the Bead to his place according to the time in the Summer hours; then bring the Bead to 4 of the clock in the Winter-hours, ſo ſhall you find the thred to fall upon 8 *deg.* and an half, and ſo much is the Sun below the Horizon at that time.

PROP. 18. *To find the time of Day-break, and end of Twy-light.*

DAy is ſaid to begin ro break when the Sun is 18 *deg.* below the Horizon in the Eaſt: and Twy-light is ſaid to end when the Sun is 18 *deg.* below the Horizon in the Weſt. Therefore rectifie the Bead for the given time, and lay the thred upon 18 *deg.* in the Quadrants Limb, the Bead among

among the contrary hour-lines ſhall ſhew the time of Twy-light.

So the time given being the 10 of *April*, ſet the Bead to the time in the Summer-hours; then bring the Bead to 18 *deg.* in the Quadrants Limb; ſo ſhall the Bead among the Winter-hour-lines fall ſomewhat more than a quarter before 3 in the morning, at which time the day begins to break.

VI. *Of the Azimuth-lines.*

PROP. 19. *Having the time of the Year and the Altitude of the Sun given, to find the Azimuth.*

YOur Bead being rectified for the time given, make obſervation of the Suns altitude; which done, bring the thred to the complement of that altitude, that is, (Count the degrees of the Suns altitude (not as they are figured upon the Quadrant, but) from

the right hand towards the left, that is, call 80 *deg.* 10 *deg.* 70 *deg.* call 20 *deg. &c.*) then will the Bead among the Azimuth-lines ſhew the Azimuth from the South, according as they are numbred.

Example: Upon the ſecond of *Auguſt* in the forenoon (having rectified the Bead for that day) I obſerved the Suns altitude to be 47 *deg.* 48 *min.* I lay the thred upon 47 *deg.* 48 *min.* counted from the right hand towards the left, and the Bead among the Azimuth-lines will fall upon that line that is figured with 40, which ſhews that the Sun is 40 *deg.* diſtant from the South towards the Eaſt, becauſe the Altitude was taken in the forenoon; whereas, if the ſame day the like altitude had been taken in the afternoon, the Azimuth would have been 40 *deg.* from the South towards the Weſt.

PROP.

PROP. 20. *The Suns Azimuth, and day of the month given, to find the Suns Altitude.*

REctifie the bead for the day given, and bring it to lie upon the Azimuth given, then will the thred lie upon the Complement of the Suns Altitude.

Thus upon the second of *August* the Suns Azimuth was observed to be 40 Degrees from the South towards the West, the bead being rectified and laid upon the fortieth Azimuth, the thred at the same time will lie upon 42 *deg.* 12 *m.* the Complement of the Suns Altitude.

Note, The Complement of the Suns altitude is so much as the altitude wants of 90 *deg.* So if the Complement of the altitude be 50 *deg.* the true altitude is 40 *deg.* if 60, then 30, *&c.*

VII. *Of the Stars upon the Quadrant.*

PROP. 21. *Having the Altitude of any of the Stars given, to find thereby the Hour of the Night.*

THe five Stars that are upon the Quadrant are these; and their Right ascensions in Hours and Minutes are as in this Table.

* *Names.*	* *Right Ascension.* H.	M.
Pegasus Wing	23	45
Arcturus	14	01
Lions Heart	9	51
Bulls Eye	4	17
Vultures Heart	19	34

Upon the 15 of *May* I see *Arcturus*, I set the Bead to it in the Quadrant, and observe his altitude, and find the altitude

altitude to be 52 *deg.* high, at which time the Bead falls upon the Hour line of 2 afternoon: This number note. Then (by the 11 *Propoſition*) I find the Right aſcenſion of the Sun to be 62 *deg.* which turned into time (by allowing 15 *deg.* for an hour, and 1 *deg.* for 4 *min.*) makes 4 *hours* 8 *min.* then the Right aſcenſion of *Arcturus* is 14 *hours* 1 *min.* the leſſer of theſe Right aſcenſions taken from the greater, leaveth 9 *hours* 53 *min.* to which add the former 2 *hours*, and it maketh 11 *hours* 53 *min.* which is the hour of the night.

A DESCRIPTION OF THE QUADRAT.

BEtween the Equinoctial and the Center of the Quadrant is a vacant place, in which is drawn a *Quadrat*, noted with these Letters A O D P, two sides whereof, namely, those fartheſt from the Center, as O D and P D, are divided each into 50 equal parts, and numbred by 10, 20, *&c.* to 50.

Of these two sides, that which is noted with O D is called the *Parts of Right Shadow*, and the other noted with P D is called the *Parts of Contrary Shadow*. Thus much for the Description of the *Quadrat*; its Use followeth.

THE

The USE of the QUADRAT.

PROP. 1. *How to take the Altitude or Height of any Tower, Tree, Steeple, or any other Object, which ſtandeth perpendicular, or upright.*

EVery Object that you look upon is either higher or lower than your Eye, or equal with it. Now ſuppoſe you ſee a Tower, and are required to find the height thereof, Lift up the Quadrant, holding it ſo that the thred may eaſily play by the ſide of it, and look through the Sights till you eſpie the top of the Tower; then go backwards or forwards till the thred fall juſt upon 50 parts, which is at D; then if you meaſure from your place of ſtanding to the foot of the Tower, and

add thereto the height from your eye to the ground, that distance shall be equal to the height of the Tower.

Example I. Thus if you do look through the Sights, and see the top of the Tower, and the thred cut just upon 50 parts of the Quadrat, and the distance from the place of your standing to the foot of the Tower be 120 foot, add thereto 5 foot for the height of your eye from the ground, and it makes 125 foot, and that is the height of the Tower.

Example II. But if the ground will not permit you to stand so that the thred may fall just upon 50 parts, then go backwards till it fall upon 25 parts of Right shadow, then will half the distance between your place of standing and the foot of the Tower, (adding the height of your eye thereto) be equal to the Towers height.

Thus looking though the Sights to the top of the Tower, and the thred falling

falling upon 25 parts of Right ſhadow, you find the diſtance from your Foot to the Tower to be (adding 5 foot your height thereto) 232 foot, the half whereof is 116 foot for the Towers height.

Example III. If again the ground will not permit you to ſtand ſo that the thred may fall upon either of theſe places, go yet farther backwards till the thred fall upon 12 parts and an half of Right ſhadow; then will one quarter of the diſtance be equal to the height. For this Rule is general:

As 50,
to the Parts on which the Thred falls,
So is the Diſtance,
to the Height.

Therefore,

Example IV. Taking a place at all adventure, where you may moſt conveniently ſtand to ſee and meaſure,

Sup-

Suppose the thred fall upon 42 parts of Right Shadow, and the distance between the Tower and your standing (with your height added) to be 86 foot: Multiply 42 (the parts cut) by 86 foot (the distance) and it makes 3612, which divide by 50 (the whole side of the *Quadrat*) and it produceth 72 $\frac{12}{50}$; which is 72 foot and almost 3 inches for the height.

When the Thred falls on the Parts of Contrary Shadow.

If the thred fall upon 25 parts, the height is double to the distance. If on 12 parts and an half, the height is four times the distance: But in general, thus;

As the Parts cut by the Thred,
are to 50:
So is the Distance,
to the Height.

Ex-

Example V. If the thred fall on 36 parts of Contrary ſhadow, and the diſtance from your ſtanding to the foot of the Tower be 23 foot: Multiply 23 (the diſtance) by 50 (the ſide of the *Quadrat*) and it maketh 1150, which divide by 36 (the parts cut of Contrary ſhadow) the Quotient is 31 $\frac{14}{36}$, that is, 31 foot 11 inches and one third part of an inch, for the height of the Tower.

Note, That what hath hitherto been ſaid concerning the taking of Heights, the ſame is to be underſtood of Diſtances alſo; only in the taking of Diſtances, Right ſhadow muſt be taken for Contrary ſhadow, and Contrary for Right.

PROP. 2. *How to take an Altitude at two Stations.*

MAny times it will fall out ſo that you cannot come cloſe to the foot

foot of the Object to meaſure, either in reſpect of water, or other hinderance, in ſuch caſes you muſt uſe 2 Stations.

Example I. Suppoſe that looking through the ſights, and ſeeing the top of the Object you would meaſure, the thred falls on 25 parts of Right ſhadow; at the ſecond Station it falls upon 20 parts: Now you muſt ſuppoſe the height of the Object to be any number of feet, as 100. Then the Proportion is

As the 25 *Parts cut at the firſt Station, is to* 50, *the Quadrats Side:*
So is 100, *the ſuppoſed Height, to* 200, *the diſtance to the Object.*

Then ſay again,

As 40, *the parts cut at the ſecond ſtation, are to* 50, *the Quadrats ſide:*
So 100, *the ſuppoſed Height, to* 250, *the diſtance from the ſecond Station to the foot of the Object.*

The

The difference between these two numbers, 250 and 200, is 50, which should be the distance between your two Stations; but measuring thereof, you find it to be but 30 foot: Then,

As 50, *the supposed difference,*
to 30, *the true difference:*
So 100, *the supposed height,*
to 60, *the true height.*

THE DESCRIPTION OF THE NOCTURNAL, FOR THE

Ready finding of the Hour of the Night, and other good Purposes.

UPon the back-side of the Quadrant may very commodiously be described a *Nocturnal*, such as Mr. *Gunter* mentions in his Book of the *Sector*: Which Nocturnal consisteth of two parts, the one fixed, and the other movable.

The fixed part consists of a Circle equally divided into 24 Hours, and those into halves and quarters. The line figured with XII represents 12 of the clock at night. The

The other part of this Nocturnal is movable, whoſe outermoſt Circle is divided into 12 parts, repreſenting the 12 Months, each Month having its name thereunto affixed, and numbred by 10, 20, *&c.* every fifth and tenth day being diſtinguiſhed from the reſt by a longer Line.

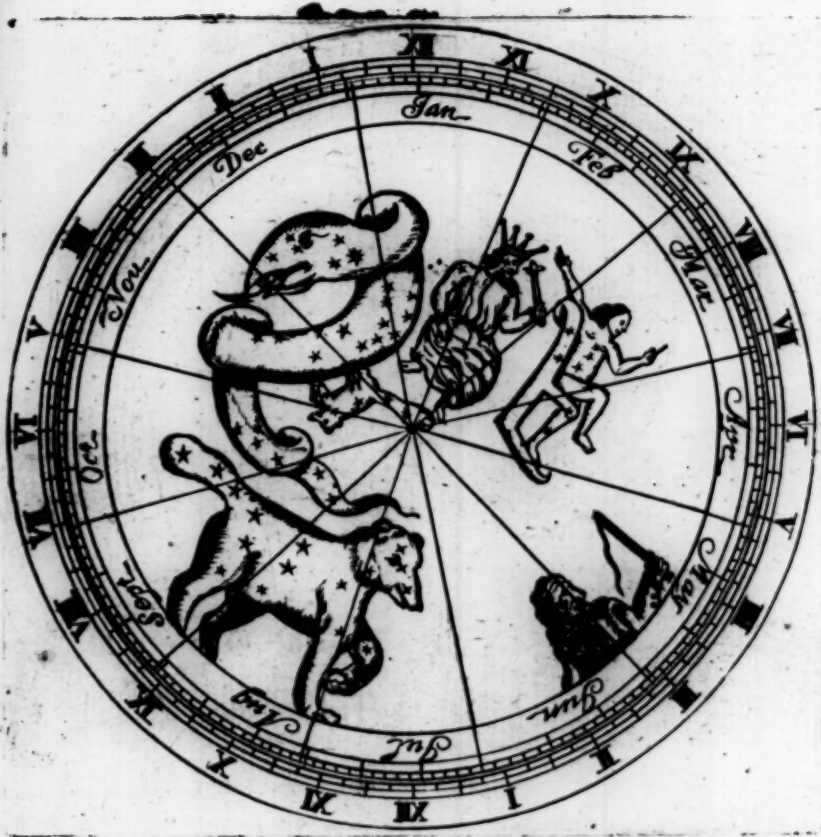
Within this Circle of Months (in ſome Nocturnals) is another Circle divided into 12 other parts, and this Circle repreſenteth the Zodiack, each part repreſenting a Sign, which hath the name or character of the Sign it repreſenteth annexed to it, and is numbred by 10, 20, 30.

In the ſuperficies of this moveable Rundle are ſeveral Conſtellations, conſiſting of thoſe eminent Stars that are near to the North Pole; the Conſtellations are in number 7, *viz. Urſa major*, or the Great Bear, *Urſa minor*, *Draco*, *Cepheus*, *Caſſiopea*, *Auriga*, *Cygnus*; as in this Rundle.

From

From the Center of this Rundle to the Circumference thereof are drawn 12 lines, repreſenting ſo many Meridians: The uſe of them will appear hereafter; and ſo let thus much ſerve for its deſcription.

THE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The USE of the NOCTURNAL.

BEfore I ſhew the Uſe of the *Nocturnal*, I ſhall (for the ſatisfaction of thoſe that do not already know how to effect it) ſhew how by the North Star to find the Meridian in the Heavens, which may be thus effected.

PROP. 1. *How to find a Meridian-line.*

THere are many ways to effect this, but the readieſt way is by the North Star, which Star is within two Degrees and an half of the North Pole. The North Pole lies about the midway between *Alioth*, or the Root of the Great Bears Tail, and this Star. Thus

you may imagine a Right line drawn from the North Star to *Alioth*, and by your imagination ſuppoſe two third parts of the diſtance of the next Star of the Little Bears Tail from the Pole-ſtar towards *Alioth*; for there is the very Pole-point, as by this Figure it doth plainly appear.

Now then if you ſet up two Poles aſlope, & from the tops of them hang two cords with weights at the ends of them, and turn them till you, ſtanding on the South ſide of them, may ſee them both together with the Pole-point, as it were all in one Right line; then do the two Cords hang in the Meridian of the place. In this Diagram I have given you the chief Stars of the Great

Great and Little Bears, ſo that by them you may come to know the other Stars that are figured in your *Nocturnal*.

PROP. 2. *How to find the Right Aſcenſion of any of the Stars in the Rundle.*

LAy the thred upon that Star whoſe Right aſcenſion you would know, then count what number of Degrees are contained between the thred and the firſt Degree of *Aries*, (counting them according to the courſe and order of the Signs) as from *Aries* by *Taurus*, *Gemini*, *&c.* to the thred, the whole number of thoſe Degrees is the Right aſcenſion of that Star.

Example. Let it be required to find the Right aſcenſion of the Star in the end of the Great Bears Tail. Lay the thred upon this Star, and it will cut the Circle which repreſenteth the Zodiack in about the 24 Degree of *Libra*, that

is, 6 Signs, which is 180 *deg.* and 24 *deg.* more, which is is in all 204 *deg.* and such is the Right ascension of the bright Star in the end of the Great Bears Tail.

PROP. 3. *To find the Declination of any of the Stars expressed in the Nocturnal.*

FOr this purpose (in some Nocturnals) one of the 12 lines that issue from the Center of the Nocturnal, is divided into unequal parts, and numbred with Arithmetical Figures. Now to find the Declination of any Star, set one foot of a pair of Compasses in the Pole or Center of the Nocturnal, and extend the other foot to the Star whose Declination is required: Then bring the moveable foot of the Compasses to the divided Meridian, and note upon what Degree it resteth, which number of Degrees being taken from 90, leaveth the Declination of the Star required. Thus

Thus if you would know the Declination of the forementioned Star, extend the Compaſſes from the Pole to the Star, this diſtance applied to the divided Meridian, will reach from the Pole to 38 *deg.* 45 *min.* which being taken from 90 *deg.* leaveth 51 *deg.* 15 *min.* for the Declination of the Star.

PROP. 4. *Any of the Stars in the Nocturnal being upon the Meridian any Day of the Year, to find thereby the Hour of the Night.*

FInd that Star upon the Nocturnal which you ſee upon the Meridian in the Heavens, and turn the Rundle about till the Star lies juſt upon the Meridian-line of 12 in the under Circle of Hours; then againſt the day of the Month in the Rundle you have the Hour of the Night in the Circle of Hours.

Ex-

Example. Upon the firſt day of *April* I ſee the Star which is in the Rump of the Great Bears Tail upon the Meridian in the Heavens; I find this Star in the Rundle, and turn the Rundle about till this Star lies juſt over the Line of 12 in the Hour-circle; then in the Rundle find the firſt of *April*, againſt the which you ſhall find in the Hour-circle 11 of the clock, and one quarter paſt, which is the Hour of the Night.

FINIS.